

What is claimed is:

1. An electrostatic actuator comprising:

a laminate substrate including a thin film silicon layer formed on a silicon substrate through a buried insulating film;

a movable structure constructed with the thin film silicon layer, wherein the movable structure includes a torsion beam and a movable side comb-tooth electrode;

a fixed side comb-tooth electrode disposed to face the movable side comb-tooth electrode, wherein the fixed side comb-tooth electrode is formed in an inside of a through hole bored through the laminate substrate, wherein a potential difference is generated between the electrodes for swinging the movable structure.

2. An electrostatic actuator according to claim 1, wherein the fixed side comb-tooth electrode is made of metal or polysilicon.

3. An electrostatic actuator according to claim 1, wherein three or more pairs of movable side and fixed side comb-tooth electrodes are provided.

4. An electrostatic actuator according to claim 1, wherein the movable side comb-tooth electrode is provided at the torsion beam of the movable structure.

5. An electrostatic actuator according to claim 1,

wherein teeth provided side by side in the movable side comb-tooth electrode and the torsion beam of the movable structure are provided to extend in a same direction, and lengths of the teeth provided side by side in the movable side comb-tooth electrode are half or more of a length of the torsion beam.

6. An electrostatic actuator according to claim 1, wherein teeth provided side by side in the fixed side comb-tooth electrode formed in the inside of the through hole are different from each other in center positions in a vertical direction.

7. An electrostatic actuator according to any one of claims 1, wherein when reflected light of a laser beam intermittently irradiated to the movable structure is emitted in a specified angle range in accordance with a swing of the movable structure, the movable structure is forcibly swung in synchronization with an intermittent irradiation period of the laser beam by the potential difference generated between the movable side comb-tooth electrode and the fixed side comb-tooth electrode.

8. An electrostatic actuator according to any one of claims 1, further comprising:

a capacity measurement fixed electrode provided on a support substrate disposed under the laminate substrate; and  
a capacity measurement movable electrode provided at the

movable structure, facing the capacity measurement fixed electrode, and performing displacement in a direction of approaching and moving away from the capacity measurement fixed electrode in accordance with the swing of the movable structure,

wherein while capacity between the capacity measurement fixed electrode and the capacity measurement movable electrode is measured to obtain a swing angle of the movable structure, the potential difference generated between the movable side comb-tooth electrode and the fixed side comb-tooth electrode is controlled to obtain a desired swing angle of the movable structure or to perform a swing operation.

9. An electrostatic actuator according to claim 1, wherein the movable structure is swung so that reflected light of a laser beam irradiated to the movable structure is directed toward a distance measurement object at a specified place in an image taken by a camera.

10. A method for manufacturing an electrostatic actuator comprised of a laminate substrate including a thin film silicon layer formed on a silicon substrate through a buried insulating film, a movable structure including a torsion beam and a movable side comb-tooth electrode, and a fixed side comb-tooth electrode disposed to face the movable side comb-tooth electrode, wherein the movable structure is constructed with the thin film silicon layer, wherein a potential difference is

generated between the electrodes to swing the movable structure, the method comprising:

- disposing the laminate substrate on a support substrate;
- forming a through hole bored through the laminate substrate in a formation area of the fixed side comb-tooth electrode in the laminate substrate, and filling the through hole with a conductive material to form the fixed side comb-tooth electrode;

- removing the thin film silicon layer and the buried insulating film around a formation area of the movable structure in the laminate substrate by trench etching; and

- removing the silicon substrate in the formation area of the movable structure by etching.

11. A method for manufacturing an electrostatic actuator comprised of a laminate substrate including a thin film silicon layer formed on a silicon substrate through a buried insulating film, a movable structure including a torsion beam and a movable side comb-tooth electrode, and a fixed side comb-tooth electrode disposed to face the movable side comb-tooth electrode, wherein the movable structure is constructed with the thin film silicon layer, wherein a potential difference is generated between the electrodes to swing the movable structure, the method comprising:

- disposing the laminate substrate on a support substrate;
- forming a through hole bored through the laminate substrate in a formation area of the fixed side comb-tooth

electrode in the laminate substrate, forming a protection film on a side wall of the through hole, and filling an inner space of the protection film with a conductive material to form the fixed side comb-tooth electrode;

removing the thin film silicon layer and the buried insulating film around a formation area of the movable structure in the laminate substrate by trench etching; and

removing the silicon substrate in the formation area of the movable structure by etching using the protection film as an etching stopper.